

## AEROLOGICAL OBSERVATIONS

By L. T. Samuels

Free-air temperatures for March were below normal at all stations with the exception of the 4 and 5 kilometer levels at Ellendale (Table 1). The largest departures occurred at Groesbeck, the southernmost station.

Free-air relative humidities were practically all above normal and the vapor pressures mostly all below normal except at the upper levels at Ellendale, where the latter were above normal. At this station it is noted that the total precipitation for the month was the second largest amount for March since the establishment of the station in 1918.

Resultant winds at the 1,000-meter level were preponderantly northerly over the northern part of the country and westerly over the South Central and Southern States. It is noted that the resultant velocities at that level were appreciably greater over the West Gulf States than over the Northern States.

At 3,000 meters the same general relation occurred except that the velocities were higher.

An ideal condition for the formation of ice on the kites and wire occurred at Due West on the 31st. With a surface temperature of 9° C. the kites entered the cloud base at 1,200 meters, where the temperature was 2° C. Within the clouds the temperature decreased to -2° C. and the kite and wire took on considerable ice, causing four kites to fall to the ground with 4,600 meters of wire.

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during March, 1931—Continued

Altitude (meters) m. s. l.	RELATIVE HUMIDITY (%)									
	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface.....	65	+1	69	+5	79	+6	75	+4	79	+8
500.....	65	+3	65	+3	79	+7	64	-3	81	+11
1,000.....	64	+5	62	+1	74	+10	60	0	81	+17
1,500.....	61	+9	63	+3	66	+8	50	-1	75	+18
2,000.....	54	+8	62	+5	63	+7	48	+5	68	+14
2,500.....	53	+11	59	+6	65	+9	41	+2	63	+11
3,000.....	54	+14	58	+11	66	+9	35	-2	58	+6
4,000.....	56	+19	38	-5	71	+18	51	+13	61	+12
5,000.....					58	+5			63	+9

VAPOR PRESSURE (mb.)

Surface.....	6.42	-1.80	6.84	-2.22	3.67	-0.27	9.05	-2.52	5.52	-0.82
500.....	5.66	-1.56	5.94	-1.98	3.61	-0.22	7.46	-2.48	4.71	-0.70
1,000.....	4.75	-1.18	4.80	-1.78	3.14	+0.12	6.09	-1.93	3.76	-0.59
1,500.....	3.93	-0.84	3.95	-1.43	2.80	+0.25	4.42	-1.67	2.94	-0.57
2,000.....	3.03	-0.67	3.38	-0.86	2.33	+0.18	3.60	-0.80	2.35	-0.61
2,500.....	2.51	-0.43	2.71	-0.52	1.96	+0.18	2.62	-0.78	1.83	-0.63
3,000.....	2.05	-0.32	2.07	-0.19	1.58	+0.14	1.89	-0.81	1.42	-0.71
4,000.....	1.41	-0.05	1.54	+0.20	1.11	+0.24	1.91	+0.05	1.09	-0.28
5,000.....					0.18	-0.38			0.79	-0.27

TABLE 1.—Free-air temperatures, relative humidities, and vapor pressures during March, 1931

TEMPERATURE (°C.)

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface.....	6.8	-3.2	6.6	-4.5	-4.1	-2.1	9.0	-4.3	1.8	-2.5
500.....	4.9	-3.4	5.3	-4.0	-4.4	-2.2	8.7	-2.9	-0.6	-2.7
1,000.....	2.9	-3.4	2.8	-3.9	-5.2	-1.7	6.6	-3.5	-3.6	-3.6
1,500.....	0.9	-3.9	0.2	-4.1	-5.2	-0.6	3.0	-3.8	-5.7	-4.5
2,000.....	-0.5	-3.5	-1.5	-3.6	-6.7	-0.3	2.8	-4.5	-7.0	-4.1
2,500.....	-2.9	-3.6	-3.2	-3.1	-9.1	-0.3	0.8	-4.3	-8.9	-3.7
3,000.....	-5.5	-2.7	-5.7	-3.4	-11.7	-0.1	-1.4	-3.9	-10.9	-3.3
4,000.....	-12.6	-5.5	-9.1	-1.9	-16.8	+0.7	-9.4	-5.7	-16.2	-3.6
5,000.....					-22.1	+0.8			-22.2	-3.4

TABLE 2.—Free-air data obtained by airplanes at naval air stations during March, 1931

Altitude (meters) m. s. l.	Temperature (°C.)				Relative humidity (%)			
	Hampton Roads, Va.	Pensacola, Fla.	San Diego, Calif.	Washington, D. C.	Hampton Roads, Va.	Pensacola, Fla.	San Diego, Calif.	Washington, D. C.
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface.....	5.7	10.7	16.9	4.1	60	72	60	64
500.....	2.7	9.3	15.5	0.7	59	67	61	68
1,000.....	-0.2	6.6	14.6	-2.0	57	63	46	68
2,000.....	-4.3	3.3	10.0	-5.6	49	55	32	58
3,000.....	-8.6	-0.7	4.6	-9.0	42	51	24	48
4,000.....		-7.2				56		

TABLE 3.—Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during March, 1931

Altitude (meters) m. s. l.	Broken Arrow, Okla. (233 meters)		Brownsville, Texas (12 meters)		Burlington, Vt. (132 meters)		Cheyenne, Wyo. (1,873 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (139 meters)		Havre, Mont. (762 meters)		Jacksonville, Fla. (14 meters)		Key West, Fla. (11 meters)		Los Angeles, Calif. (127 meters)		Medford, Oreg. (410 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
Surface.....	N 23 W	1.3	S 25 W	0.5	N 27 E	0.5	N 75 W	5.7	N 81 W	0.6	N 15 W	1.9	N 33 W	1.1	S 59 W	1.6	N 75 W	1.4	N 27 E	0.9	N 33 E	2.0	N 20 W	0.1
500.....	N 7 W	1.4	S 11 W	4.0	N 22 W	1.8	N 75 W	1.6	N 67 W	1.6	N 15 W	1.9	N 69 W	2.5	S 22 E	0.3	N 60 W	6.0	S 22 E	0.3	N 68 E	1.2	S 74 W	0.4
1,000.....	N 85 W	2.7	S 86 W	2.6	N 30 W	0.7	N 75 W	3.7	N 75 W	3.7	N 14 W	2.2	N 66 W	5.4	S 78 W	3.6	N 78 W	6.7	S 68 W	3.3	N 3 E	2.4	S 40 W	1.0
1,500.....	N 63 W	0.8	N 78 W	3.4	N 30 W	0.8	N 74 W	5.4	N 74 W	5.4	N 44 W	3.2	N 49 W	7.0	N 78 W	7.0	N 85 W	7.8	S 70 W	4.8	N 8 W	2.8	S 80 W	2.4
2,000.....	N 54 W	8.4	N 82 W	3.9	N 30 W	1.6	N 70 W	8.9	N 70 W	8.6	N 39 W	3.6	N 54 W	8.0	N 74 W	7.8	N 82 W	10.7	S 78 W	5.9	N 20 W	3.6	S 51 W	2.5
2,500.....	N 25 W	12.5	N 65 W	7.4	N 53 W	1.5	N 64 W	13.4	N 74 W	10.7	N 40 W	3.1	N 41 W	11.1	N 71 W	8.5	N 78 W	12.6	S 86 W	7.7	N 25 W	2.8	S 75 W	3.2
3,000.....			N 63 W	9.9	N 86 W	3.6	N 49 W	11.4	N 63 W	12.0	N 56 W	3.6	N 40 W	12.7	N 70 W	8.9	N 82 W	15.3	N 88 W	9.3	N 34 W	4.6	N 66 W	3.4
4,000.....			N 64 W	9.8	S 77 W	7.3	N 52 W	12.2	N 60 W	13.6	N 47 W	3.6					N 82 W	16.7	N 78 W	12.0	N 24 W	6.5	N 46 W	2.7
5,000.....									N 69 W	17.7							N 88 W	18.9						

TABLE 3.—Free-air resultant winds (meters per second) based on pilot balloon observations made near 7 a. m. (E. S. T.) during March, 1931—Continued

Altitude (meters) m. s. l.	Memphis, Tenn. (145 meters)		Modena, Utah (1,665 meters)		New Or- leans, La. (25 meters)		Omaha, Nebr. (299 meters)		Phoenix, Ariz. (356 meters)		Royal Center, Ind. (225 meters)		Salt Lake City, Utah (1,294 meters)		San Fran- cisco, Calif. (8 meters)		Sault Ste. Marie, Mich. (198 meters)		Seattle, Wash. (14 meters)		Spokane, Wash. (606 meters)		Washing- ton, D. C. (10 meters)	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Surface...	S 69 W	1.0	N 79 W	2.0	N 36 W	1.3	N 21 E	1.7	S 86 E	2.4	N 39 W	1.4	S 4 E	1.7	S 47 E	0.4	N 45 E	1.4	S 19 E	1.5	S 16 E	1.6	N 28 W	2.0
500.....	N 82 W	1.9	-----	-----	N 53 W	3.4	N 17 E	2.0	N 82 E	2.3	N 15 W	2.7	-----	-----	N 27 W	2.5	N 51 E	4.3	S 19 W	1.5	-----	-----	N 18 W	5.6
1,000.....	N 69 W	5.5	-----	-----	N 71 W	4.2	N 2 W	2.5	N 19 E	1.5	N 5 E	3.1	-----	-----	N 14 W	4.9	N 54 E	2.7	S 33 W	6.3	S 30 W	4.3	N 38 W	7.0
1,500.....	N 67 W	6.9	-----	-----	N 77 W	4.7	N 25 W	5.5	N 20 W	1.7	N 1 W	3.7	S 11 E	2.2	N 25 W	4.2	N 41 E	3.3	S 68 W	3.7	S 62 W	4.9	N 32 W	7.2
2,000.....	N 78 W	7.9	N 13 E	1.3	N 70 W	6.7	N 35 W	7.1	N 46 W	2.5	N 29 W	4.8	S 65 W	1.4	N 28 W	3.8	N 67 E	3.6	N 71 W	3.3	S 86 W	4.9	N 64 W	7.0
2,500.....	N 71 W	9.0	N 3 W	2.8	N 69 W	9.1	N 33 W	9.0	N 36 W	4.1	N 30 W	5.6	N 69 W	3.5	N 47 W	6.0	N 4 E	3.0	N 2 W	3.1	N 81 W	6.3	N 59 W	8.0
3,000.....	-----	-----	N 20 W	4.8	N 80 W	9.9	N 45 W	10.0	N 39 W	5.6	N 44 W	6.0	N 55 W	5.5	N 56 W	5.9	N 20 W	4.1	N 4 E	5.9	N 89 W	6.2	N 64 W	9.2
4,000.....	-----	-----	N 45 W	9.1	-----	-----	N 34 W	12.4	N 49 W	6.2	N 61 W	8.4	N 52 W	6.0	N 43 W	5.1	N 12 E	6.7	-----	-----	-----	-----	N 78 W	13.4
5,000.....	-----	-----	N 48 W	13.1	-----	-----	-----	-----	-----	-----	-----	-----	N 19 W	11.4	-----	-----	N 28 W	6.4	-----	-----	-----	-----	-----	-----

TABLE 4.—Observations by means of kites, captive and limited height sounding balloons during March, 1931

	Broken Arrow, Okla.	Due West, S. C.	Ellen- dale, N. Dak.	Groes- beck, Tex.	Royal Center, Ind.
Mean altitudes (meters), m. s. l., reached during month.....	2,608	2,517	3,184	2,222	2,864
Maximum altitude (meters), m. s. l., reached.....	4,498	4,493	4,998	4,264	19,445
Number of flights made.....	34	33	33	30	33
Number of days on which flights were made.....	30	31	28	30	30

In addition to the above, there were approximately 176 pilot balloon observations made daily at 60 Weather Bureau stations in the United States.

<sup>1</sup> Limited-height sounding balloon observation.

## WEATHER IN THE UNITED STATES

### THE WEATHER ELEMENTS

By M. C. BENNETT

#### GENERAL SUMMARY

The weather for March, as a whole, was persistently cool throughout the central and southern portions of the country from the Rocky Mountains eastward to the Atlantic, while the northern and western sections were warm for the season; however, during the last week a severe cold wave overspread the northwestern and central-western areas, and in some sections the lowest temperatures of the winter occurred during this period, with heavy snow as far south as northwestern Texas.

For the month as a whole the precipitation continued below normal in most sections east of the Great Plains and in large areas west of the Rocky Mountains. The Pacific Northwest, the Great Plains and the extreme Southeast, and the North Atlantic section had much more than the average, while a few localities received nearly twice the normal. The greatest shortage occurred from the Ohio Valley southward nearly to the Gulf and in the far Southwest, especially the lower Colorado Valley, Nevada, and southern California.

#### TEMPERATURE

The first decade of March was mainly warmer than normal near the Pacific coast and in the northern portion of the country, but colder than normal in the middle and southern portions from the Sierra crest to the Atlantic coast. The period from the 6th to 9th was especially cold in the middle and southern Plateau, Rocky Mountain, and Plains regions.

The fortnight from the 11th to the 24th was mostly warmer than normal in the western half of the country

and from Minnesota to New England, but colder than normal in the middle and southern portions of the eastern half, especially the South Atlantic and East Gulf States.

The final week of March was marked almost everywhere by cold weather, especially from the western Plateau to the Mississippi River. The districts from the Black Hills southward to northwestern Texas and central Oklahoma averaged at least 15° colder than normal. However, most of California and the Northeast continued warmer than normal.

The month averaged warmer than normal in the Pacific States and a large part of the Plateau region, also in the northernmost third of the country. The northern portions of New England and New York and the vicinity of Lake Superior and the Red River of the North averaged mainly 4° to 6° above normal. The most marked excess of the monthly temperature was in southwestern California, where Los Angeles noted a mean of 66°, over 8° above normal, making this not only the warmest March but warmer than any recorded April or May.

From New Mexico and eastern Utah eastward to the Atlantic coast from Delaware Bay to Florida the month averaged colder than normal, and to the southward of the Potomac and Ohio Rivers and the southern parts of Missouri and Kansas the deficiency averaged 4° to 7°. In Florida it was almost the coldest March ever known.

The highest marks were generally not notable for March, but one station each in Arizona and California noted 100°. In many States, even as far south as Missouri and Virginia, no temperature exceeding 70° was recorded. In the western half the highest temperatures usually occurred about the 22d, near the Mississippi River about the 13th, but from Michigan and the middle Ohio Valley eastward between the 23d and the 28th.

The lowest readings were considerably below zero in the northernmost States and as far south as Nebraska; also in